Warmtepompen in smart grids: nooit zonder thermische opslag

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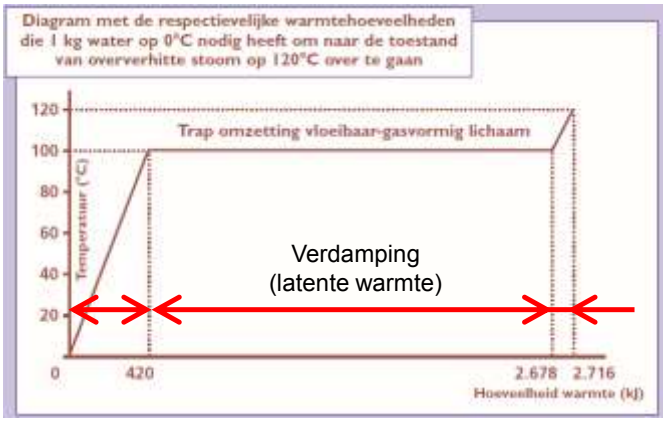
Werking van een warmtepomp

- 3 fysische verschijnselen
  - Verdamping van een vloeistof ➔ warmte in
    Condensatie van een vloeistof ➔ warmte uit
  - Kookpunt = functie(druk)
  - Gas: Temperatuur stijgt als druk stijgt

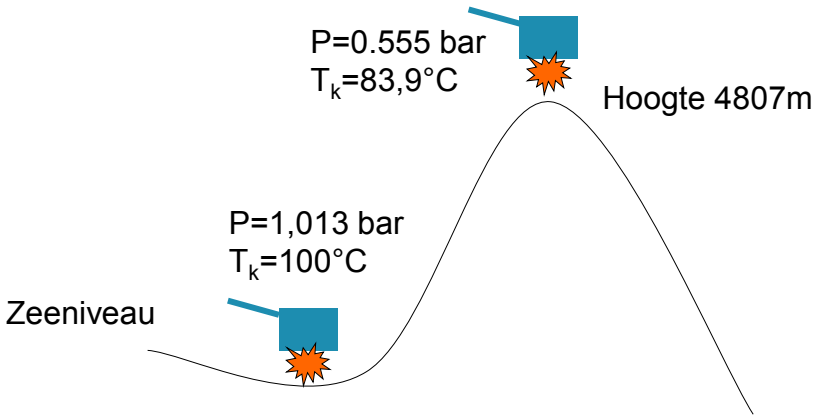
(1) Verdampingswarmte



[1]

(2) Kookpunt = functie(druk)

- Het 'Mont Blanc' voorbeeld

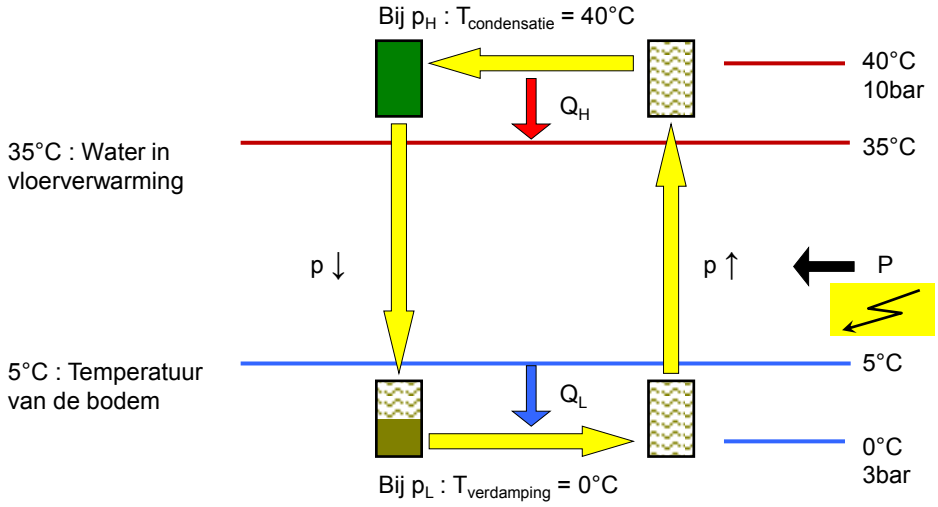


(3) Gas: Temperatuur stijgt als druk stijgt

- Voor een ideaal gas:

$$\frac{T^{\kappa}}{p^{(\kappa-1)}} = constant\ (\kappa \cong 1{,}4)$$

Werking van een warmtepomp



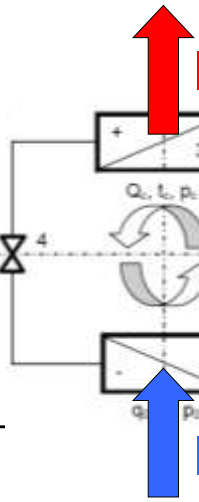
Werking van een warmtepomp

$$Q_H = Q_L + P$$

$$4 = 3 + 1$$

$$COP = \frac{\dot{Q}_H\,[W]}{\dot{P}\,[W]}$$

$$SPF = \frac{Q_H\,[kWh]}{P\,[kWh]}$$



Condensor (Q_H)

Warmteafgifte op hoge temperatuur

Compressor (P)

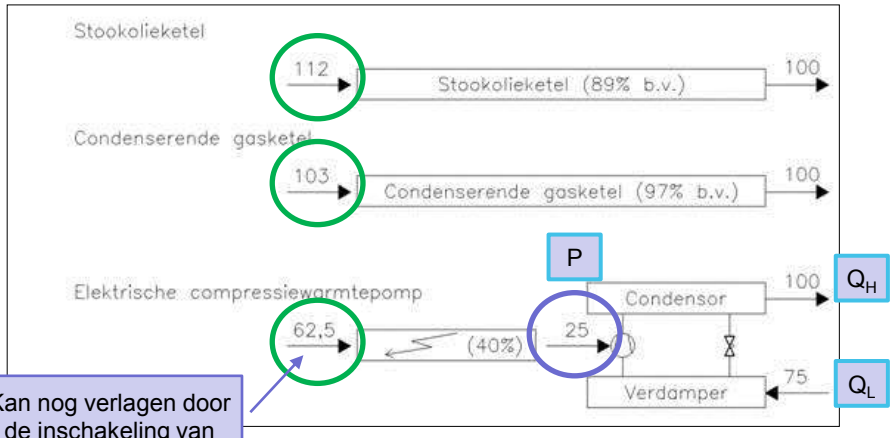
Elektriciteit als compressiearbeid

Warmtetoevoer op lage temperatuur

Verdamper (Q_L)

Smart grids en warmtepompen

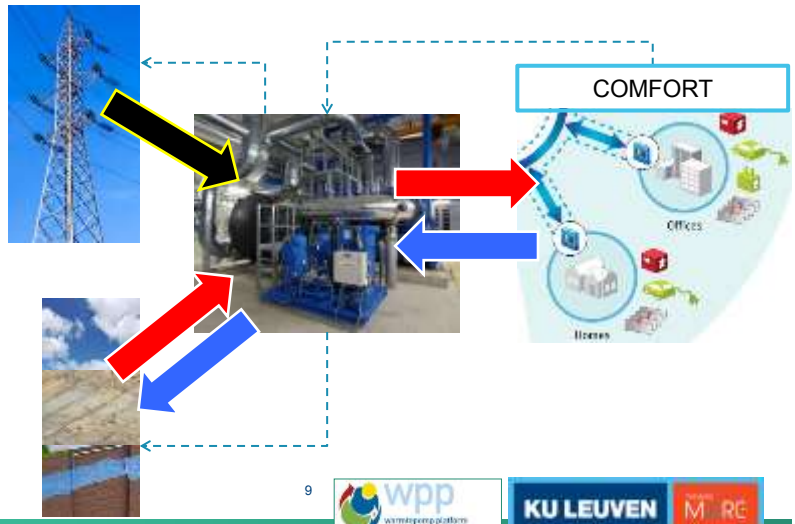
- Elektrificatie van verwarming en koeling



Kan nog verlagen door de inschakeling van hernieuwbare energie

[5]

Warmtepomp: vraaggedreven



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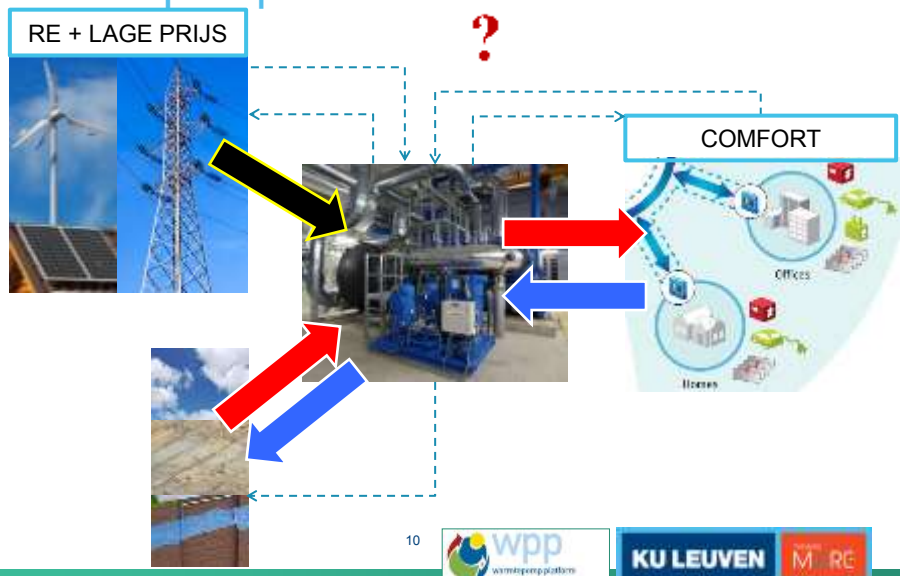
Warmtepomp: aanbodgedreven?



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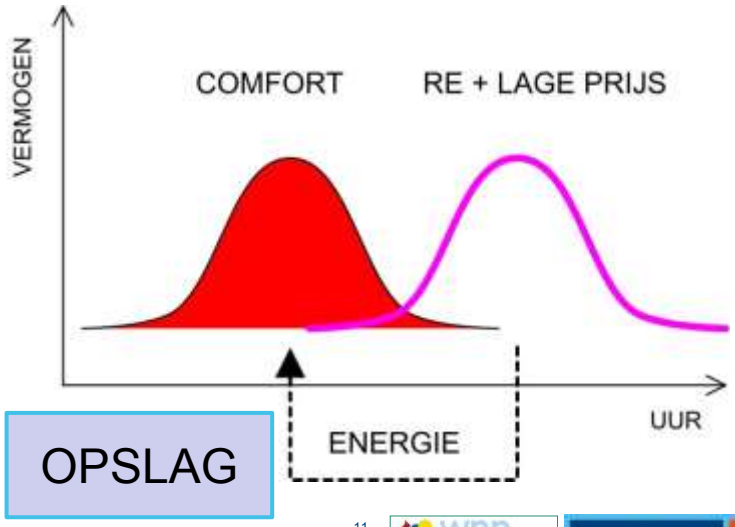
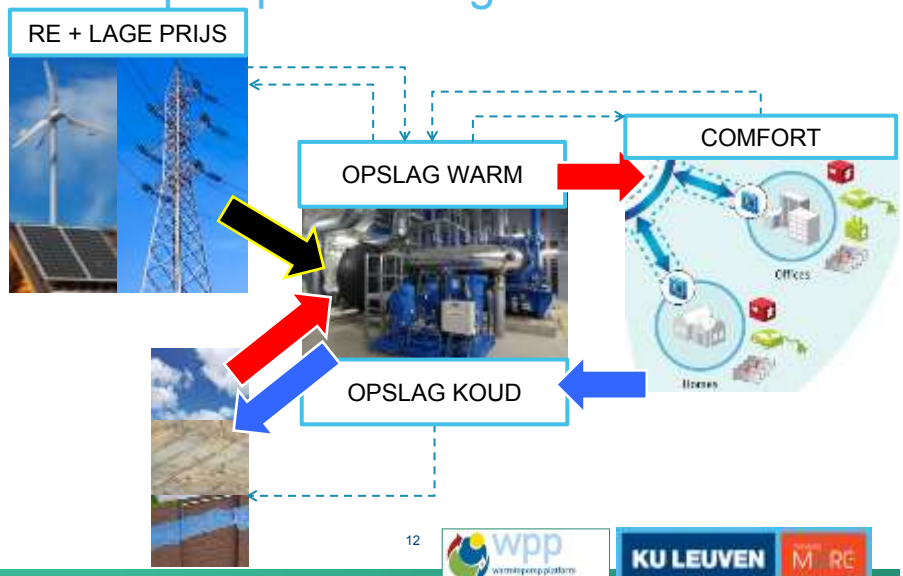
Warmtepomp: aanbodgedreven?

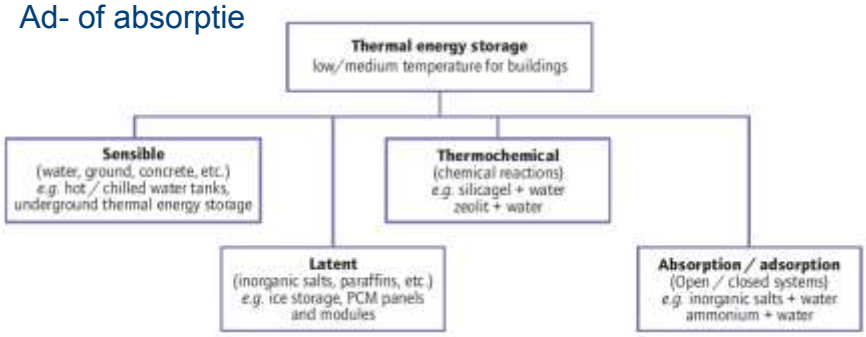


Warmtepomp: aanbodgedreven?



Types van thermische opslag

- Voelbaar: Water, gebouwmassa, ...
- Latent: fase-verandering
- Thermo-chemisch
- Ad- of absorptie



Types van thermische opslag

Table 6: Energy capacities, power, efficiency and storage time of thermal energy storage technologies

TES technology	Capacity kWh/t	Power kW	Efficiency (%)	Storage time	Cost (USD/kWh)
Hot water tank	20-80	1-10 000	50-90	day-year	0.1-0.13
Chilled water tank	10-20	1-2 000	70-90	hour-week	0.1-0.13
ATES low temp.	5-10	500-10 000	50-90	day-year	Varies
BTES low temp.	5-30	100-5 000	50-90	day-year	Varies
PCM-general	50-150	1-1 000	75-90	hour-week	13-65
Ice storage tank	100	100-1 000	80-90	hour-week	6-20
Thermal-chemical	120-150	10-1 000	75-100	hour-day	10-52

Source: ECES and Roth, K. Zogg, R. and Brodrick, J. (2006).
Note: ATES stands for aquifer thermal energy storage and BTES stands for borehole thermal energy storage.

[3]

Types van thermische opslag

Table 1. Comparison of various heat storage media (stored energy = 10^6 kJ = 300 kWh; ΔT = 15 K)

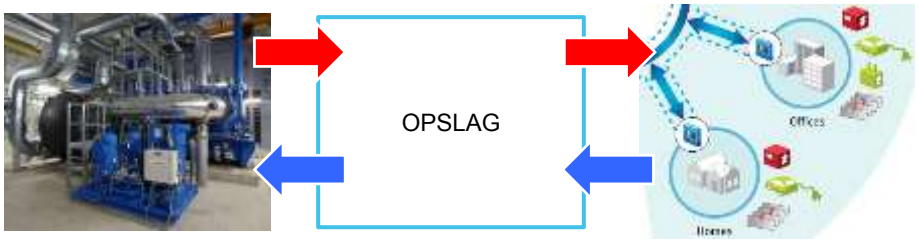
	Heat Storage Material			
	Sensible heat storage		Phase Change Materials	
Property	Rock	Water	Organic	Inorganic
Latent heat of fusion (kJ/kg)	*	*	190	230
Specific heat (kJ/kg)	1.0	4.2	2.0	2.0
Density (kg/m^3)	2240	1000	800	1600
Storage mass for storing 10^6 kJ (kg)	67000	16000	5300	4350
Relative mass**	15	4	1.25	1.0
Storage volume for storing 10^6 kJ (m^3)	30	16	6.6	2.7
Relative volume**	11	6	2.5	1.0

*Latent heat of fusion is not of interest for sensible heat storage.
**Relative mass and volume are based on latent heat storage in inorganic phase change materials

[4]

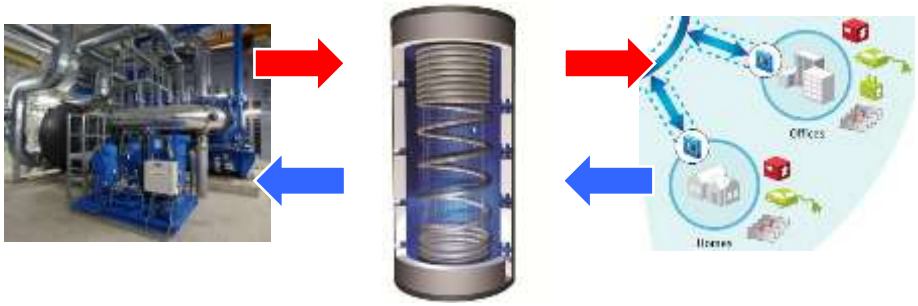
Thermische opslag: vereisten

- Hoge en regelbare vermogenuitwisseling in en uit!



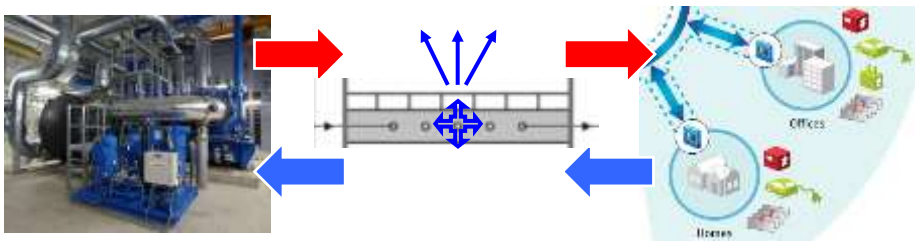
Thermische opslag: vereisten

- Hoge en regelbare vermogenuitwisseling in en uit!
  - Voelbare warmte: water ➔ OK



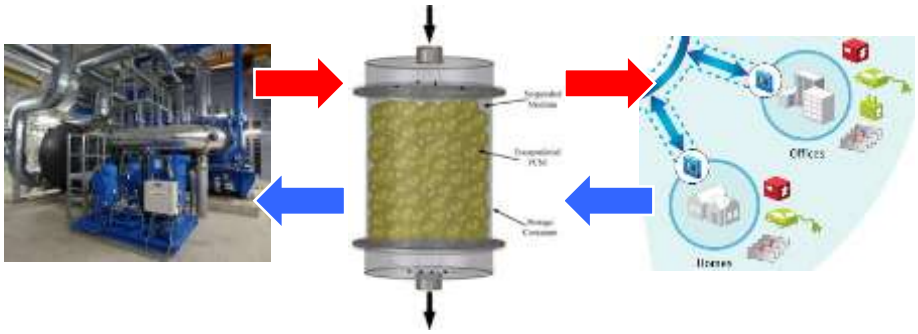
Thermische opslag: vereisten

- Hoge en regelbare vermogenuitwisseling in en uit!
  - Voelbare warmte: beton ➔ niet OK

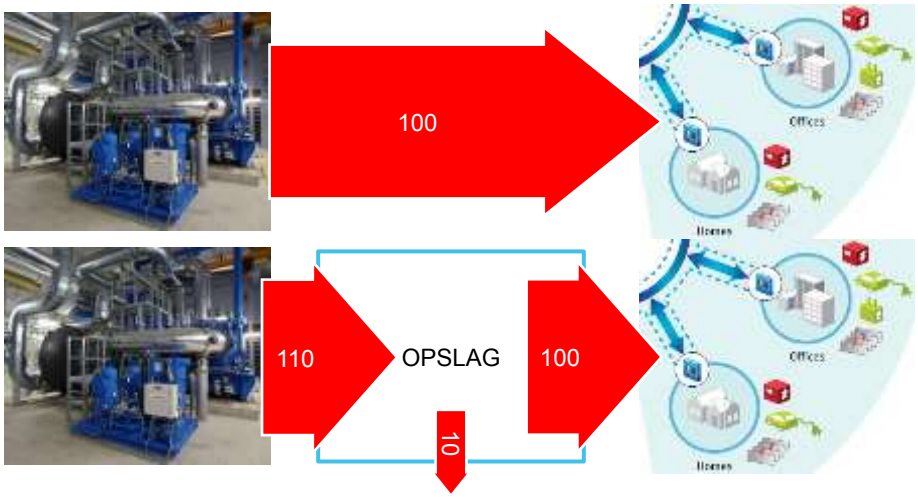


Thermische opslag: vereisten

- Hoge en regelbare vermogenuitwisseling in en uit!
  - Latente warmte: PCM ➔ niet OK



Thermische opslag = regelverlies



Warmtepomp en smart grids

Heat pumps, combined heat & power and cooling installations could play an important role in smart electricity grids if thermal production can be decoupled from thermal demand. [2]

There is a need to develop, in line with Smart-Grid / Smart-Homes technologies, methods to accurately determine the state of charge, controls and control algorithms so that heating and cooling is optimally generated from the RES (e.g. night time excess wind energy / PV) when available, while still providing the consumer with their needs at a time of their choosing. [2]

The establishment of an open source communication protocol for Smart Grids / Smart Homes would enable manufacturers to create and commercialise devices that are compatible with many systems. [2]

Warmtepomp en smart grids

- Opportuniteiten in combinatie met thermische opslag
  - Elektrische verwarming en koeling
  - Regelbare elektrische verbruiker (zie eig. opslag)
- Dubbele waardeverhoging
  - Dienst aan gebruiker: comfort
  - Dienst aan elektriciteitsnet: balancering

Dank u wel!

Bronnen

1. Warmtepompen voor woningverwarming, ODE in opdracht van het Ministerie van de Vlaamse Gemeenschap, 2002
2. Strategic Research Priorities for Cross-cutting Technology, European Technology Platform on Renewable Heating and Cooling, 2012
3. IEA Technology Roadmap, Energy-efficient Buildings: Heating and Cooling Equipment, 2011
4. S.M. Hasnain, Review on sustainable thermal energy storage technologies, Part I: heat storage materials and techniques, Energy Conversion and Management, Volume 39, Issue 11, 1 August 1998, Pages 1127-1138
5. ISSO Handboek Installatietechniek